Trends and research on Off-Grid Solar Power Plants to realize the 7th SDG's

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Abstract. This study aims to examine the role, trends, and progression of Off-Grid Solar Power Plants in advancing the 7th SDGs. The research methodology employed involves bibliometric analysis utilizing VOSviewer and Biblioshiny tools. VOSviewer and Biblioshiny are used to scrutinize the annual distribution of documents across different countries, institutions, journals, and authors and to determine the interrelation among keywords. The results reveal that Indonesia ranks among the top 10 contributing countries among the 10 countries/regions involved in developing Off-Grid Solar Power Plants. The data utilized in this research is sourced from the Scopus database in .csv format. Alongside data extraction from the Scopus database, this study also investigates the implementation of Off-Grid Solar Power Plants and their installation in the DI Yogyakarta Province.

1 Introduction

Bibliometric analysis is a technique utilized to examine extensive quantities of scientific data with quantitative approaches and descriptive statistics, which can produce significant research impact [1, 2]. This approach examines published article trends to generate an evaluation and categorization of bibliographic records [3]. The range of bibliometric analysis is extensive, encompassing the scrutiny of research trends within a subject, co-authorship examination, identification of the most prolific countries, and assessment of journals or keywords frequently employed as research subjects [4, 5]. The expansive scope of bibliometric analysis enhances the precision and thoroughness of initial research stages on a topic [6, 7]. Engaging in bibliometric analysis is crucial for gaining insights into the evolution of research associated with a specific subject [7, 8, 9]. Examining topics such as Off-Grid Solar Power Plants is particularly significant.

Research on trend analysis using bibliometrics has been conducted over the past few decades [10]. Based on data from Scopus accessed on July 1, 2024 (www.scopus.com),

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between 2019 and 2023, indexed international journals containing Off-Grid Solar Power Plants were 1654 documents from all countries. Within the research field, publications serve as crucial sources for learning and writing, particularly internationally indexed. Scopus holds significant importance as a top international index that guides researchers worldwide in disseminating their research findings [11, 12].

Nevertheless, achieving publication in Scopus is challenging as it demands the exploration of novel research themes. Studies indicate that aligning with emerging trends can boost publication rates in recent years [13, 14, 15], consequently influencing the evolution of research themes. Hence, staying informed about current trends, especially in Off-Grid Solar Power Generation, is crucial.

Given these concerns and the critical need for action, reviewing research topics concerning off-grid solar power plants to achieve the 7th SDG is essential globally to recognize prevailing research trends. The aspiration is that the outcomes of this study can offer valuable insights to researchers in the future. Moreover, this study intends to investigate research patterns and offer insights into the future landscape of Off-Grid Solar Power Plants.

This study outlines the trends and research on Off-Grid Solar Power Plants for achieving the 7th SDG to identify and compare its research, which can help future researchers.

- Regarding research characteristics and features, where are the locations, document types, sources, and authors of Off-Grid Solar Power Plants for supporting the 7th SDG's research?
- What are the dominant disciplines in terms of application, and how do Off-Grid Solar Power Plants contribute to supporting the 7th SDGs?

2 Methods

Bibliometrics is a statistical technique used to assess and measure publications in a particular research field, thereby reducing subjectivity and potential bias [16, 17]. This method helps researchers in understanding the structure, patterns, and trends in research activities across different disciplines [18, 19].

2.1 Resources

Data was collected from the Scopus database which has a more detailed coverage of the development of Off-Grid Solar Power Plants than similar databases such as WOS [20].

2.2 Data collection

The five steps of bibliometric analysis include Determining search Keywords, Initial Research Results, Refinement of search results, Compile preliminary data statistics, and Data analysis. In this research, the author chose the keyword, "OFF-Grid". In the refinement stage, the author limited the data based on coverage and year of publication. The time span covered is from January 2019 to December 2023. As a result, there were 1,654 documents relevant to Off-Grid Solar Power Plants research. Each data was downloaded in .csv formats.

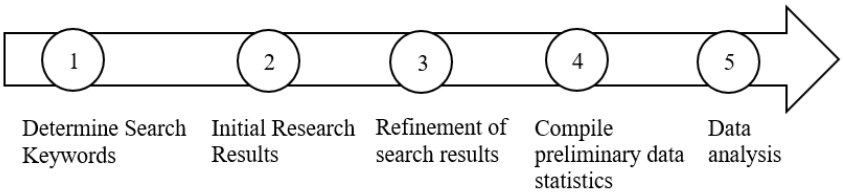

Fig. 1. Step by step of bibliometric analysis.

2.3 Data analysis

The data was examined using VosViewer & Biblioshiny software to uncover connections among authors, documents, and keywords [20, 21]. Information such as publication year, country, affiliation, language, and more was assessed from the .csv file using Microsoft Excel.

3 Results and Discussion

3.1 Publication by year

The results of metadata conducted on the Scopus database found that there were 1654 international indexed journal documents (all countries) on the topic of Off-Grid Solar Power Plants from 2019 to 2023. In detail, the number of metadata will be described in Table 1 below.

Table 1. Document details by year

Year 2019-2023	Total Document
2019	283
2020	286
2021	347
2022	347
2023	391

Table 1 shows That for the publication of documents in the year (2019-2023) International (all countries), There are fluctuations in each publication, where there is an increase in 2019-2021 in each publication, while in 2021-2022, the total number of documents does not increase; and in 2022-2023 there is again an increase in each publication. This indicates that publications on off-grid solar power plants each year do not experience a decline, and the existing trend continues to increase yearly.

3.2 Top 10 authors

The metadata results conducted by the Scopus database based on the top authors in international indexed journals found that Ocon, J. D. had 11 articles; Jurado, F. had 10 articles; Wan, L had 8 articles; Rezkallah, M. had 8 articles; Jurasz, J. had 8 articles; Chandra, A. had 8 articles; Wang, X. had 7 articles; Singh, B. had 7 articles; Poli, D. had 7 articles and Misak, S. had 7 articles. In detail, the number of metadata Authors will be described in Figure 2 below.

Fig. 2. Top 10 Authors

3.3 Top 10 affiliation

The metadata results conducted by the Scopus database based on the top affiliation in international indexed journals found that the University of Theran had 38 articles; the Delft University of Technology had 37 articles; the National University of Defense Technology 36 had articles; the University of the Philippines Diliman had 36 articles; Xidian University had 36 articles; Notreported had 32 articles; Politecnico Di Mi'lano had 32 articles; North China Eletic Power University had 31 articles; Southeast University had 15 articles and Tsinghuai had 31 articles. In detail, the amount of metadata Affiliation will be described in Figure 3 below.

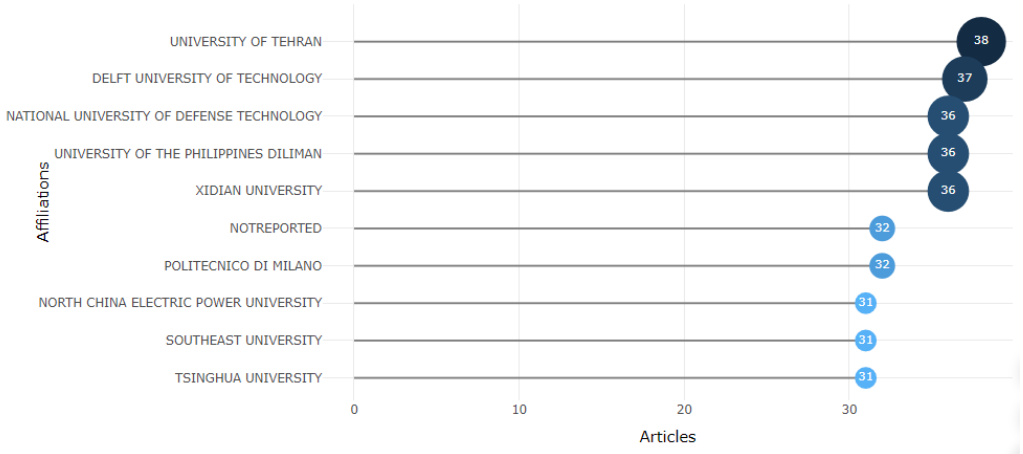

Fig. 3. Top 10 Affiliation

3.4 Top 10 Country/Territory

The metadata results conducted by the Scopus database based on the top Country/Territory in international indexed journals found that China had 273 articles; India had 110 articles; the USA had 60 articles; Iran had 45 articles; the United Kingdom had 38 articles; Germany

had 30 articles; Spain had 30 articles; Italy had 29 articles; Nigeria had 28 articles and Indonesia had 52 articles. In detail, the amount of metadata Country/Territory will be described in Figure 4 below.

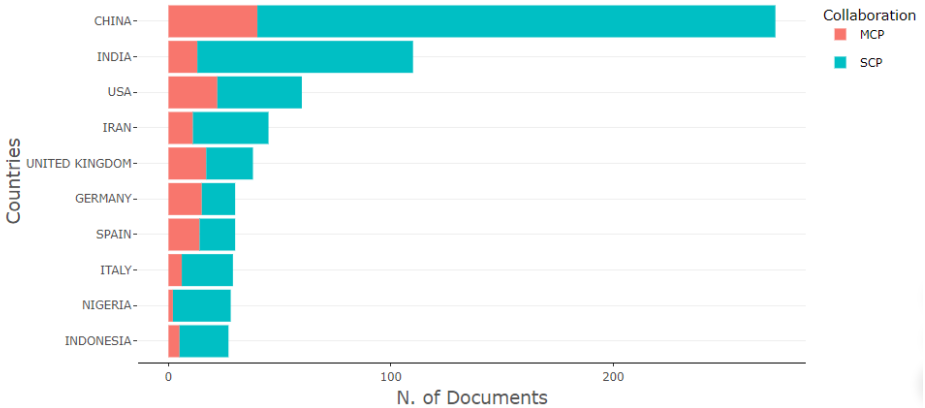

Fig. 4. Top 10 Country/Territory

3.5 Visualization of research trends

The results of visualizing research trends conducted on the Scopus database in internationally indexed journals (all countries) using VOSviewer software in detail will be described in Figure 5 below. While the visualization of research trends carried out using Biblioshiny software in detail will be described in Figure 6 below.

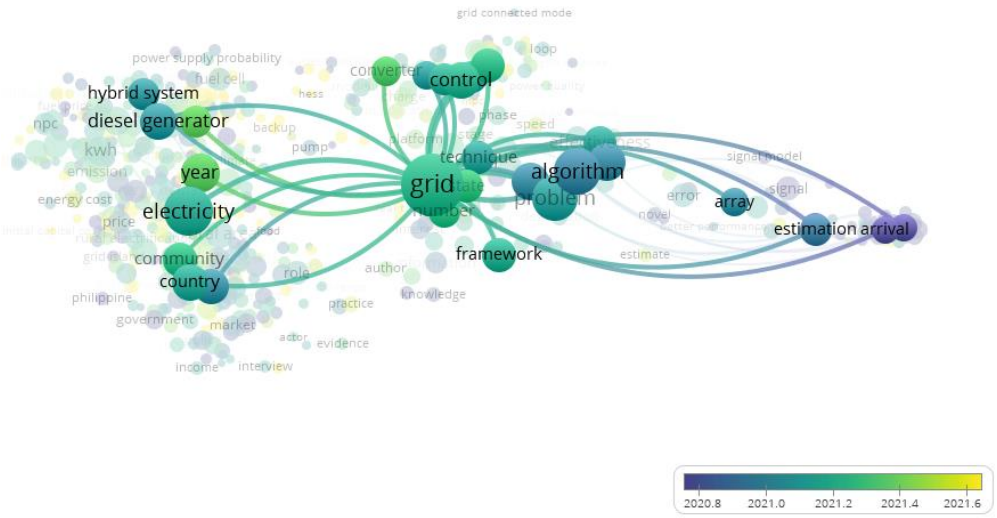

Fig. 5. Visualization of Research Trends using VosViewer

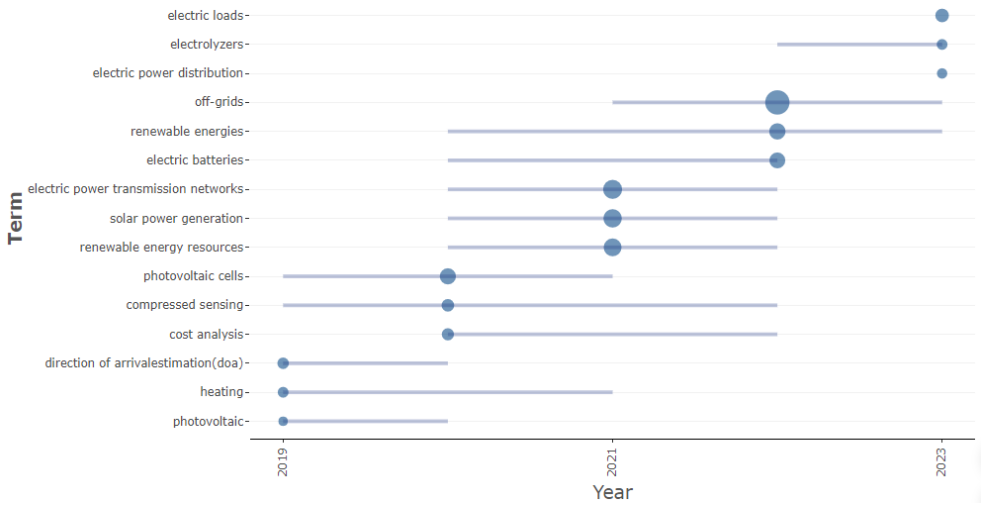

Fig. 6. Visualization of Research Trends using Biblioshiny

3.6 Review of Off-Grid Solar Power Plant most cited papers from 2019 to 2023

Table 2 presents an evaluation of the three most frequently cited and highly influential publications in the field of Off-Grid Solar Power Plant from 2019 to 2023. Each of these articles was analyzed based on citations, Scimago Journal and Country Rank (SJR) data retrieved from www.scimagojr.com and CiteScore data accessed at www.scopus.com as of July 2024. The analysis included a review of the findings and recommendations presented in each publication [23-26].

Table 2. Review of Most Cited Paper Publication from 2019 to 2022

Author(s)	Citation	SJR	H-Index	Findings & Recommendations
Xu, C. et al. (2020) [27]	236	Q1 (2.55)	250	The findings show that the off-grid wind/PV (photovoltaic)/hydrogen/solar power plants system can run optimally with 83.2 kW PV panels, a 160 kW wind turbine, a 20 kW fuel cell, a 54 kW electrolyzer, and a 450 m3 hydrogen storage tank, with an LCOE of 0.226 $/kWh, an LPSP of 4.01%, and a PAR of 2.15%.
Abdin, Z. & Merida, W. (2019) [28]	235	Q1 (2.55)	250	The findings show that an off-grid wind / PV / hydrogen / solar power generation system can run optimally by integrating photovoltaic (PV), WT (wind turbines), battery bank, electrolyzer, and hydrogen tank reaching 0.50 $/kWh in Golden, Colorado, USA.
Ghenai, C., Salameh, T., & Merabet, A. (2020) [29]	223	Q1 (1.51)	263	The findings show that an off-grid wind/PV/hydrogen/solar power generation system can run optimally having a 40.2% renewable fraction, is economically viable with a levelized energy cost of 145$/MWh and is environmentally friendly (zero carbon

				dioxide emissions during electricity generation from the solar PV and Fuel Cell hybrid power system).

In addition, based on Table 2, those publications form the basis for future research, so they have outstanding citations and impact on the development of Off-Grid Solar Power Plant. As of July 2023, a list of the most cited publications in Quartile 1 (Q1) ranked journals, with Citation ranging from 223 to 236, is provided. This indicates that these publications have significant influence and unquestionable credibility, especially due to the reputable nature of the publishers. The SJR indicator analysis assigns different values to citations based on the significance of the source journal from which the citation originated. As a result, citations from influential journals have a more significant value, and journals that receive such citations tend to gain greater recognition and prominence.

3.7 The Application for Off-Grid Solar Power Plant to Realize the 7th SDG's

Off-Grid Solar Power Plant utilizes the energy generated by solar panels mounted on top of lights. In addition to generating electricity, solar panels also produce unused heat. However, this excess heat can be utilized as an additional source of electrical energy through the use of thermoelectric generator modules. Taking advantage of the temperature difference in the thermoelectric generator module, additional electrical energy can be generated without wasting heat. The generated electrical energy is then stored in the same battery used by the rooftop solar power plant. The function of the equipment in the Off-Grid Solar Power Plant is shown in Table 3.

Table 3. The function of the equipment in the Off-Grid Solar Power Plant

No	Tools	Function
1	Solar Cell	A solar cell, also known as a photovoltaic cell, is a technology that captures sunlight to generate electrical power, which can then be stored in a battery.
2	Solar Charge Controller (SCC)	SCC is a device utilized as a link to connect solar cell devices for the purpose of charging batteries.
3	Battery	The battery acts as a reservoir for the electricity generated by the solar cell, which is then supplied to the load.
4	Inverter	The inverter functions as a DC current converter on the battery so that it can be used in AC current on the load.
5	Thermoelectric	Thermoelectric modules function to convert heat energy from temperature gradients into electrical energy or vice versa from electrical energy into temperature gradients.

In addition to the functions of each component described in table 2, the detailed Component assembly of the Off-Grid Solar Power Plant is shown in Figure 7 below.

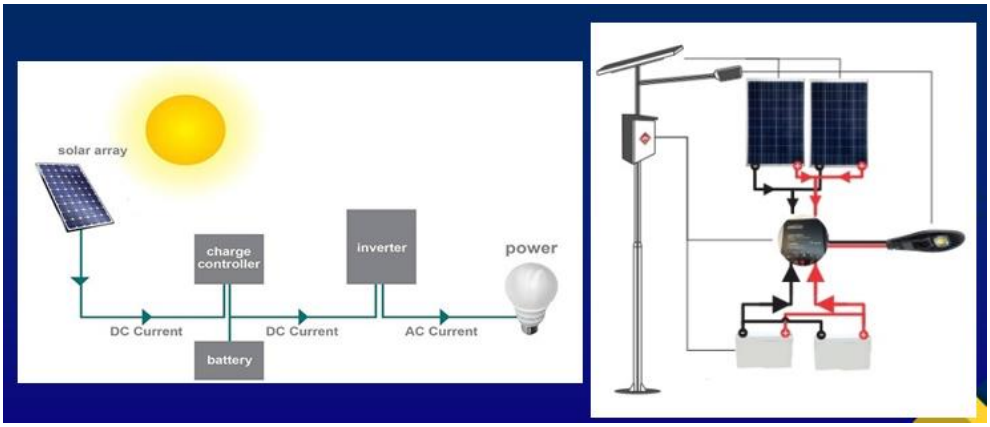

Fig. 7. The detailed Component assembly

After the assembly process of each component, the installation of the Off-Grid Solar Power Plant to Realize the 7th SDG's is carried out as shown in Figure 8 below the results of the installation carried out in D.I Yogyakarta Province.

Fig. 8. The Installation Off-Grid Solar Power Plant

Reviewing research topics concerning off-grid solar power plants to achieve the 7th SDG is essential globally to recognize prevailing research trends. This study outlines the trends and research on Off-Grid Solar Power Plants for achieving the 7th SDG to identify and compare its research, which can help future researchers. The results of the study [30-36] strengthen the findings of this study that the profile of trends and citations of a study can contribute positively to strategic policy-making and future research.

4 Conclusion

This research explores the role of Off-Grid Solar Power Plants in supporting the 7th SDG, focusing on its trends, applications, and contributions. The research found that Off-Grid Solar Power Plant had a stable trend in research over the past five years and there is no downward trend from 2019-2023. This research only uses metadata from Scopus. This study found that Trends Visualization both using Biblioshiny and using VosViewer every year always

progresses by looking at the topic every year. This study found that Indonesia is included in the 10 Countries/Territories that develop Off-Grid Solar Power Plant so that it can be predicted that the research trend will continue to increase every year along with the Indonesian government policy that provides incentives on green energy so that it can be.

Acknowledgements

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